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ABSTRACT

The purpose of this study is to present information that will help educators to gain a better understanding of microcomputer capabilities and limitations and to inform them as to the role of microcomputers in the classroom. Through examination of studies and articles six topics related to computer-assisted instruction (CAI) are addressed: (1) age groups, ability levels, and subjects with which CAI can be used; (2) effectiveness of CAI in producing achievement gains; (3) other effects of CAI on student development; (4) effects of CAI on attitudes of students and teachers concerning computers; (5) advantages of CAI over other methods of instruction; and (6) limitations of CAI. Annotations of the studies, reviews, and articles examined are divided into six main sections dealing with applications, effects on students' academic and personal growth, advantages and limitations of CAI, and suggestions for more effective use of CAI. It is concluded that CAI can become a valuable learning tool that can be used at many age and ability levels, and that it can result in computer literacy and achievement gains, improved self concepts, and learning motivation. It is cautioned, however, that CAI is neither a cure-all nor suitable for all students, but must be considered one of many instructional methods. Based on the findings of CAI research, several recommendations are made for improved needs assessment by schools and teachers, development of computer literacy, and future research. A 67-item bibliography is included. (MES)

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A STUDY OF COMPUTER-ASSISTED INSTRUCTION: ITS USES, EFFECTS, ADVANTAGES, AND LIMITATIONS

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of course E591--Exit Project
March 1986

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INTRODUCTION

In past years, the computer has been widely used in the areas of business, industry, and medicine. Although the field of education has been interested in the usage of computers, the cost of a computer system was well outside the budgets of most school corporations (Pressman and Rosembloom, 1984). With the advent of microcomputers, the schools have again considered the use of computers. Microcomputers are far less expensive than earlier computer systems (McDermott and Watkins, 1983). They have proven to be of great value in the administrative area of education. Educators are now beginning to use the microcomputer in the classroom as a means of providing instruction to students (Steele, Battista, and Krockover, 1983). This type of instruction has been labelled computer-assisted instruction.

Computer-assisted instruction (CAI) is defined in many ways but is generally defined as "instruction which is assisted or aided through the use of the computer" (Harrod and Ruggles, 1983, p. 3). There are many types of computer-assisted instruction programs. Most programs fall into one of six categories:

1) Drill and Practice----used to reinforce regular classroom instruction.
2) Tutorial----used to teach rules and concepts, evaluate the student's understanding of the

concepts, and allow practice in the skills being taught.

3) Simulation----used when learning basic concepts and principles. The student interacts with, and becomes a part of the simulation.

4) Problem-solving----used to apply already learned skills, which in turn helps develop new problem-solving skills.

5) Demonstration----used to help explain a concept through visual presentations.

6) Mini-programming ----designed to help teachers learn to make their own programs, usually crossword puzzles or word searches (Harrod and Ruggles 1983, pp. 5-6.

According to Harrod and Ruggles (1983), and Saracho (1982), the major types of CAI programs now being used in education are those of drill-and-practice and tutorial.

Before CAI is used in the classroom, it is necessary that administrators and educators have a good understanding of the uses, advantages, and limitations of the microcomputer in relation to instruction, and that they also understand the effects of computer-assisted instruction on both student and teacher.

STATEMENT OF THE PROBLEM

Microcomputers have made a large impact on many segments of our society. In recent years, computer manufacturers and parent groups have strongly urged the schools to use microcomputers in the classroom as a means of exposing students to the new technology. Thus, many schools have purchased computer systems, but with little understanding of how to implement or successfully use them. Therefore, in order to use computers and CAI in a way that will be of benefit to students and teachers, it is necessary to study the uses, effects, advantages, and limitations of computers and computer-assisted instruction.

THE PURPOSE OF THE STUDY

The purpose of this study is twofold: to present information that will help educators gain a better understanding of microcomputer capabilities and limitations, and to inform educators as to the role of microcomputers in classroom instruction.

Through the examination of studies and articles, it is hoped that several questions about CAI can be answered: 1) With what age groups, ability levels, and subjects can CAI be used? 2) Is CAI effective in producing achievement gains? 3) Does CAI affect aspects of student development other than achievement? 4) What effect does CAI have on the attitudes of students and teachers concerning computers? 5) What are

the advantages in using CAI over other methods of instruction? 6) What limitations does CAI have?

ORGANIZATION OF THE STUDY

The studies, reviews, and articles pertaining to CAI that were examined in this study, are abstracted on the following pages, with a summary of the research, conclusions, and recommendations completing the study.

Annotations are divided into five main sections dealing with applications, effects on the student, advantages, limitations, and suggestions for the successful use of CAI in education. Within each main section, each annotation is arranged according to the subtopic it discusses.

In the first section, Applications, there are few annotations. Although information concerning the use of the microcomputer is contained in many of the research studies, most of the studies emphasize the effects, advantages, or limitations of computer-assisted instruction. Therefore, these annotations have been placed in sections appropriate to their emphasis.

DEFINITION OF TERMS

academic learning time---the amount of engaged time spent in high success activities (Bright: 148).

branching---a method of selecting the next instruction for the computer to execute, based on the results of previous operations (Baur and Pigford: 1).

CAI phenomenon---a phenomenon attributed to CAI in which equal learning is produced in less time (Bright: 144).

compliance---the child's response to teacher direction, including compliance to instructions and attention to tasks (Clements and Nastasi: 15).

computer-assisted instruction (CAI)---instruction which is assisted or aided through the use of the computer (Harrod and Ruggles: 3).

computer-based education (CBE)---used synonymously with CAI.

computer-based instruction (CBI)---used interchangeably with CAI and CBE.

computer literacy---the progression from comfort with technology through skills and knowledge acquisition to ultimately using the computer as a personal tool (Harrod and Ruggles: 3).

computer-managed instruction (CMI)--- the systematic control of instruction by the computer (Zaharias: 993 citing Burke: 188).

corrective feedback---feedback which identifies the incorrect response as wrong, gives the student a corrective procedure, and encourages the student to try again (Hodes: 250).

cost-effectiveness---more learning for the same cost or equivalent learning for less cost (Spuck: 12).

courseware---software designed to teach a specific topic (Beasley: 156).

drill-and-practice---a CAI program in which a problem or exercise is presented, the student responds, and is given immediate feedback (Saracho: 203 citing Muscat, Lorton, and Orler, 1977).

effectance motivation---the degree to which the child desires to control or effect change in the environment. This includes independent self-directed work; internal locus of control; intrinsic motivation; attitudes toward learning (curiosity, enthusiasm); and pleasure at intellectual discovery (Clements and Nastasi: 15).

engaged time---the time a student is attentive to the instruction being presented (Bright: 147).

engagement rates---the amount of time a student is engaged in the instruction being presented (Bright: 147).

hardware---the physical equipment or devices which together comprise a computer and associated data processing machines (Baur and Pigford: 4).

Hawthorne Effect---shows that the novelty of a change itself sometimes produces temporary improvement (Bracey: 52).

Language-Experience Approach---an integrated language arts program which builds upon the interrelationship between and among reading and the related language arts of writing, speaking, and listening; use is made of individual and group compositions as reading materials (Goode: 329).

learning style---the preference for a particular sensory modality: visual, auditory, or kinesthetic (motor) (Duncan: 8).

LOGO---a computer language which encourages learning through exploration and discovery (Duncan: 9).

noncorrective feedback---feedback which identifies the incorrect response as wrong, gives no corrective procedure to the student, gives no encouragement to try gain, and may occasionally "put down" the student (Hodes: 251).

self-esteem---a person's judgement of the self-concept he/she has formed; an estimate of whether his/her self-concept reaches his/her standards and values (Page and Thomas: 306).

social problem-solving---the ability to effectively apply problem-solving skills to real-life social situations, reflected in the ability to work and play cooperatively, and the ability to successfully resolve conflicts without adult intervention (Clements and Nastasi: 13).

social sensitivity---the awareness of others' feelings, a concern for their needs, and a willingness to share and help (Clements and Nastasi: 14).

software---elaborate sets of instructions which allow computer hardware to perform specific functions (Beasley: 156).

time-on-task hypothesis---the more academic learning time a student accumulates the more the student is learning (Bright: 148 citing Fisher et al., 1980: 8).

tutorial---a new concept is presented, immediate feedback is given to student responses, and tutorial assistance is offered to help the students understand and correct their mistakes using additional exercises (Saracho: 203 citing Muscat, Lorton, and Oler, 1977).

word processing---a computer program which allows a student to write, edit, and print documents (Brunken: 130).

ANNOTATIONS

APPLICATIONS OF COMPUTER ASSISTED INSTRUCTION

In The Curriculum

Bradley, Virginia N. "Improving Students' Writing with Microcomputers." Language Arts 59 (October 1982): 732-743.

Bradley describes four categories of computer use which are helpful in improving students' writing: 1) stimulating the generation of ideas, 2) computer mail systems, 3) text analysis, and 4) word processing.

In the category of stimulating ideas, CAI programs are used. Students using the CAI programs felt that the programs made them think more systematically about their writing (Burns, 1979). However, two studies, both by Woodruff and Bereiter (1981), found that the quality of writing was not improved when using CAI writing programs with sixth graders.

Electronic mail, in which students can write letters to one another via the computer, has been used in a school for the deaf, where over 1500 letters in one year were written using this system (Rubenstein and Rollins, 1978).

Text analysis programs scan compositions for structural mistakes. Students then correct errors pointed out.

Word processing programs have encouraged children to reread their compositions and to revise their work where needed.

Two studies by the author, one involving using the computer in a language experience approach, and the other using the word processor in a sentence combining activity, produced favorable results. Students in the language experience approach groups wrote longer stories, contributed eagerly, and suggested revisions while creating the stories. The other group successfully completed sentence combining tasks.

Rushakoff, Gary E. "Microcomputer Assisted Instruction in Communication Disorders." Journal of Childhood Communication Disorders 8 (Fall-Winter 1984): 51-61.

Rushakoff describes four different types of CAI: 1) drill and practice, 2) tutorial, 3) problem-solving, and 4) simulation. He suggests that problem-solving and simulation programs would be useful in training speech and hearing majors due to the programs' ability to present "real-life" situations in which the student has to make decisions and solve problems.

Discussion focuses on creating courseware for speech and hearing majors, the aspects of courseware design, and the assessment of courseware.

Rushakoff also addresses time-savings, learning retention, learner attitudes toward the courseware, and the costs of CAI systems. In a study done by Rushakoff and his colleagues (1983), students in anatomy and physiology classes favored the use of CAI. Most students felt the CAI lessons had helped them, and they wanted to use CAI more often.

One study (Trujillo, 1983) and one review of CAI literature (Edwards, et al., 1975) found that students took less time to learn using CAI than through other methods.

Conflicting studies concerning learning retention were reviewed. Thomas (1979) found CAI retention equal to that of traditional instruction while Edwards et al. (1975) found CAI learning retention to be lower than that found in traditional instruction.

A report on the costs of CAI (Pressman and Rosenbloom, 1984) indicated that costs are declining. Rushakoff and Lombardino (1984) believe that overall costs of CAI systems may be shared among the various applications of speech and hearing programs.

To Varied Student Populations

Beasley, William A. "The Role of Microcomputers in the Education of the Gifted." Roeper Review 7 (February 1985): 156-159.

Beasley agrees with Stuart Smith (1983), who contends that students must develop skills which will enable them to receive and use information made available to them through the use of the computer.

Gifted children, because of a wide range of interests and the ability to retain large quantities of information (Clark, 1983), need a broad range of subject matter, as well as development of higher level thinking skills (Maker, 1982).

Through the use of the computer, these aspects of learning can be achieved. Computer-assisted instruction can be used to introduce the gifted student to a new content area (tutorial), and can also, through the use of simulation programs, provide the student the chance to explore the effect of variables upon a given situation.

Beasley describes other uses of the computer in educating the gifted such as using it as a research tool, as a means of creating music, art, and written pieces, and as a means of creating programming. He contends that if used in an appropriate manner, the computer can be a means to thinking and learning more effectively.

Walkington, Pat, and Eloise Babcock. "Educational Computing and the Gifted Child: A How-to-Approach." Teaching Exceptional Children 16 (Summer 1984): 266-269.

The authors advocate the use of computers to help gifted children move rapidly through content areas, so that these students do not become bored and disinterested in learning. Computer-assisted instruction can be used to teach new concepts and monitor student progress. However, an important aspect of a CAI program is that it offers flexibility to the student rather than just routine drill and practice.

Computer programming can be used to help a student develop creativeness and problem-solving skills.

Guidelines for computer planning with gifted students are presented with emphasis on giving achievement tests to determine at what level each student should start new learning, and also making certain that software is flexible and motivating.

Vaac, Nancy N. "Computer in Adult Education." Lifelong Learning 7 (April 1984): 26-28.

The intent of this article is to discuss possible reasons for the lack of reported computer use with adult learners, and to describe ways computers have and could be used in adult education.

Reasons for the lack of CAI use with adults include adult educators' beliefs that the computer, a product-oriented tool, cannot fit into the realm of adult education, which is process-oriented (Meierhenry, 1982). Other factors which limit CAI use in adult education are the misconceptions about computers, the limited amount of software appropriate to this group of learners, and the tendency for most adults to prefer traditional methods of instruction (Carp, Peterson, Roelfs, 1974).

Areas in which CAI can be used with adult learners are those of reading and writing. In reading, the computer can be used to increase reading speed, learn spelling words, combine sentences, study vocabulary words, assist in developing visual discrimination, and aid in comprehension.

In writing, word processor programs are used to encourage students to edit and revise their writing. Students are actively involved in their learning, and attitudes are improved (Southwell, 1982).

Brunken, Phyllis. "Independence for the Visually Handicapped Through Technology." Education of the Visually Handicapped 15 (Winter 1984): 127-133.

At the Nebraska School for the Visually Handicapped, the computer has had a big impact. A computer lab was set up consisting of microcomputers, VersaBraille systems, printers, voice synthesizer systems, a Brailler, and other pieces of equipment used in the teaching of the visually handicapped.

Students from ages 10 to 19 received training in the use of this equipment, and then used the training for word processing, computer literacy, programming, and computer-assisted instruction. A student's success in the computer technology program was based upon his/her knowledge of the keyboard, development of listening skills, ability to follow directions, level of cognitive development, and level of literacy in print or braille.

Brunken maintains that with the use of the computer, more barriers are being removed for the visually handicapped, which allows for more learner freedom: freedom to use print media; freedom to write error-free documents; freedom to choose from a wide range of careers, and freedom to be independent.

Dowling, Barry. "Microcomputers Behind Bars: CAI for Juvenile Delinquents." Classroom Computer News 3 (September-October, 1982): 42.

Computer-assisted instruction was used in the reading curriculum at the Fred C. Nelles School in Whittier, California. Students at this school are wards of the California Youth Authority. They live at the school and have been placed there for crimes ranging from vandalism to murder. Ages range from 13 to 18, and many cannot read above a second-grade level.

The main goal of the school is to help the student change his perception of himself as being controlled by others or by "fate", to seeing himself as a person who can control and shape his own life. Because CAI has been considered by many to be nonthreatening, as well as offering positive feedback, a CAI program was used to see if these CAI characteristics would improve a student's skill in reading, and if such a program would also help a student gain a better perspective about his ability to control his life.

Generally, the students' reading skill levels improved by an average of one month for each month of CAI use. Most students remain at the school for 5 years thus allowing them the possibility of making great gains in achievement. No information was given as to the effect of CAI on the student's feeling of being in control.

EFFECTS OF COMPUTER-ASSISTED INSTRUCTION

On Academic Growth & Development

Achievement

Anderson, Ronald E., and others. "The Affective and Cognitive Effects of Microcomputer-Based Science Instruction." Journal of Educational Technology Systems 9 (1980-81): 329-355.

This study was designed to investigate the impact of a short CAI science experience on the achievement, beliefs, and attitudes of 350 randomly selected 9th and 11th grade students in one high school. Those involved in the study were assigned to one of four different treatment groups. Two CAI groups were given the regular science lesson, one was given the lesson with enriched display, and the last group encountered a computer malfunction during the lesson.

The effects of the CAI experience on achievement were favorable as CAI students correctly answered twice as many test items as did the non-CAI students. CAI students also had higher scores on the follow-up exam given six months later.

In addition, the students in the CAI groups became less anxious about the computer, became more confident in their computer abilities, and expressed greater enjoyment in using the computer. The CAI group encountering the computer malfunction had a lesser degree of confidence in computer abilities, and months later, expected the computer to fail. The enriched display given to one group seemed to have no effect on attitudes.

Saracho, Olivia N. "The Effects of a Computer-Assisted Instruction Program on Basic Skills Achievement and Attitudes Toward Instruction of Spanish-Speaking Migrant Children." American Educational Research Journal 19 (Summer 1982): 201-219.

Two-hundred and fifty-six Spanish-speaking migrant children in grades 3-6 participated in a study which assessed the effects of CAI on achievement gains, and on attitudes toward instruction. Each member of the experimental (CAI) group received CAI three hours each week for five months in addition to regular classroom instruction. The non-CAI group received only classroom instruction.

Differences were assessed in three areas: grade level, instruction, and sex of the students. Those students who used the CAI program scored significantly higher on achievement posttests than did those in the non-CAI group. Fourth grade CAI students had greater improvement in reading and language than did students in the other grades, while 3rd graders had the least improvement.

For mathematics, 4th and 5th graders made the greatest gains, while 6th graders made the least. Also, the area of mathematics was the only area in which significant differences in improvement was found between boys and girls. Boys improved more than girls.

Attitude scores indicated no significant differences in grade or sex, but between groups, there were differences in attitude toward instruction. Students in the non-CAI group had more favorable attitudes toward CAI than did students who had received CAI.

Teague, Gerald V., Robert M. Wilson, and Marianne G. Teague. "Use of Computer-Assisted Instruction to Improve Spelling Proficiency of Low Achieving First Graders." AEDS Journal 17 (Summer 1984): 30-35.

Seven first graders, who were low achievers in spelling, were given CAI in spelling for a 25 minute period four days a week for five consecutive weeks. Prior to CAI, performance scores on five weekly spelling tests were charted for each participant. Weekly scores were also charted during the five week period that CAI was used. At the beginning of the 11th week, a 10 word spelling test, comprised of words learned from the CAI programs, was given to assess retention.

The results of the study showed that, using CAI programs, six of the seven participants improved in spelling performance. The scores of one child actually dropped, possibly due to a fear of the computer. It is important to note that CAI may not be appropriate for all children, and in fact may be counter-productive.

Retention scores of the students ranged from 50%-100% correct, with five of seven students scoring 80% or higher.

Bracey, Gerald W. "Computers in Education: What the Research Shows." Electronic Learning 2 (November-December 1982): 51-54.

Bracey reports on the achievement, affective/motivational, and social outcomes of computer use. Generalizations were based on the meta-analysis study of James Kulik (to be published in 1983) and the studies by the Educational Testing Service (ETS).

In the Kulik study, CAI students scored better on objective tests, improved retention, and learned a given amount of material in less time than did non-CAI students.

The ETS studies, which lasted four years, found CAI to be an effective learning aid over the long-term as well the short-term period. It was also shown that CAI could be easily replicated.

The affective/motivational outcomes were positive in both studies. Those students using CAI emerged with more positive attitudes about computers, enjoyed moving at their own pace, felt more in control of things, and were relieved of the embarrassment of making mistakes.

Neither study investigated the effect of CAI on social development. However, Bracey and his colleagues have observed that collaborative, cooperative problem-solving activities occurred among those students involved in computer programming.

Dence, Marie. "Toward Defining the Role of CAI: A Review." Educational Technology 20 (November 1980): 50-54.

Dence relates the findings of 17 studies on CAI done in the 1970's. Findings indicate that foreign languages and the sciences are areas in which CAI is consistently effective (Koch, 1973; Magidson, 1978).

Branching in CAI is more effective than non-branching (Coulson and others, 1970), and feedback results in greater achievement gains (Tait, Hartley, and Anderson, 1974). CAI also provides individualized instruction that a student may not receive in a large classroom setting (Magidson, 1977).

Compared to traditional instruction, CAI results in equal or better performance gains (Magidson, 1978; Lewellen, 1971; Allen, 1972). Tsai and Pohl (1978) found that students who had both CAI and traditional instruction scored higher on final exams than did either group using separate treatments.

Savings in learning time of CAI students was 40% in Allen's study (1972), and 50-66% in the study of Bitzer and Alpert (1970). Bitzer and Alpert also reported that students had higher retention scores in the CAI group on a test given 26 weeks after CAI instruction.

Edwards, Judith, et al. "How Effective is CAI? A Review of the Research." Educational Leadership 33 (November 1975): 147-153.

The authors review CAI studies in which time-savings, retention of learning, and effectiveness according to ability level were assessed. Studies also reviewed were those which determined the effectiveness of CAI as a supplement to and substitute for traditional instruction, and those which compared the effectiveness of different modes of CAI. Comparison with non-traditional methods of instruction such as programmed instruction and filmstrips was also assessed.

Findings from the studies indicated that CAI was most effective used as a supplement to traditional instruction rather than as a substitute. Compared to other non-traditional methods of instruction, CAI proved to be equally effective. Each mode of CAI was equally or more effective than traditional instruction, but no CAI mode was more effective than another.

CAI mathematics drill-and-practice was most effective with low-ability students. Retention studies indicated retention of learning was equal to or less than learning obtained through traditional means.

All nine studies measuring time-savings reported that it took less time for students to learn through CAI than through other methods.

Forman, Denyse. "Search of the Literature." The Computing Teacher 9 (January 1982): 37-51.

Based on the review of literature, Forman discusses several aspects of CAI: 1) effects on achievement, 2) cost-effectiveness, 3) advantages, and 4) impediments to CAI implementation in the schools. When compared to traditional instruction, CAI either equalled or improved learning in less time, regardless of the type of CAI used, the type of computer system, or the age of the students. Students exhibited more positive attitudes toward CAI, were more motivated, and increased their attention span and attendance (Hallworth and Brebner, 1980). In relation to cost-effectiveness, Forman estimates the cost of CAI use as $1.00 per student hour. However, this estimate does not include maintenance costs or courseware development. She also cites Norris (1978) who noted that traditional instructional costs have risen at a rate of 13% per year while CAI costs have decreased at a rate of 3% per year. Hidden benefits of using CAI include the use of the computer for other purposes, the decrease in vandalism and truancy, and the compatibility for more flexible scheduling and wider course alternatives.

In addition to the advantages of individualization, immediate feedback and reinforcement, and monitoring progress, CAI frees the teacher to devote more time to the personal aspects of the student.

Impediments to the use of CAI in the schools include insufficient funding, poorly constructed CAI materials, confusing computer languages and hardware systems, poor teacher attitudes, and a lack of trained educators in the use of the computer and CAI materials.

McCaslin, Pamela S., and Linda B. Stevens. "Immediate Openings." The Pointer 28 (Winter 1984): 16-19.

Four studies that measured the effects of CAI on learning disabled students were reviewed. Also an example of a "shell program," one in which one or more question-and-answer formats are presented, is discussed.

In Alice Chiang's study of 200 handicapped children (1978), the CAI group's gains from September to May were positive in 3\4 of the students. Teachers had used a "shell program," and were very pleased with the results. During the school year, over 800 other programs in language arts and math were developed using this program.

Kleiman, Humphrey, and VanBuskirk (1981) compared the performance of hyperactive children on mathematics problems given by computer and those given by paper and pencil. In comparing accuracy, number of problems attempted, and rate in problem solving, a large difference was noted in the number of problems attempted. Twice as many problems were attempted due to twice as much time voluntarily spent at the computer. Thus, CAI may increase the attention span of hyperactive children.

Roman and Laudato (1974) found that CAI improved students' ability to translate mathematical word problems into number sentences.

A study by John J. Trifilette (1982) found that children given CAI gained twice as many mathematical skills as the control group during the five month study, gained more mathematics skills during the school year, and achieved a mean of eight months academic gain compared to three months gain for the non-CAI group.

Kulik, James A., Chen-Lin C. Kulik, and Peter A. Cohen. "Effectiveness of Computer-based College Teaching: A Meta-analysis of Findings." Review of Educational Research 50 (Winter 1980): 525-544.

In this meta-analysis of CBI effects on college students, Kulik and his colleagues analyzed the findings of 59 studies describing the outcomes of student achievement, correlation between aptitude and achievement, course completion, student attitudes, and instructional time.

Of 54 studies assessing achievement, CBI examination performance was superior to non-CBI performance in 37 studies. In seven studies reporting aptitude-achievement correlations, CBI had no significant effect. There were also no significant effects found in the 13 studies that examined the effect of CBI on course completion.

With respect to student attitude outcomes, there were small effects for CBI students on attitudes toward CBI instruction and toward subject matter.

The most conclusive finding involved instructional time. In all eight studies that investigated this issue, there was a substantial savings in instructional time. It is clear that in college courses computers can produce achievement gains in less time.

Kulik, James A., Robert L. Bangert, and George W. Williams. "Effects of Computer-based Teaching on Secondary School Students." Journal of Educational Psychology 75 (February 1983): 19-26.

Fifty-one studies on the effectiveness of computer-based instruction on students in grades 6-12 were reviewed. In the area of achievement gains, results in 39 studies indicated that CBI classes scored higher than did the control groups. In 23 studies, scores for the CBI classes were significantly higher.

Five of the 51 studies gave follow-up exams to test retention. In four of the five studies, CBI classes had higher retention scores than the control groups, but not significantly higher.

Ten studies reported on students' attitudes toward the subject matter being taught. Eight studies reported more positive attitudes by CBI students, with two studies reporting significant improvement.

Results on students' attitudes toward the computer were reported in four studies, with all CBI groups improving attitudes. Three of the four improved significantly.

Four other studies reported on student ratings of quality instruction. CBI classes in these studies expressed more favorable ratings, but not significantly so.

In relation to time taken to learn, only two studies addressed this issue. One study indicated a savings of 39%; the other study, 88%.

Compared to Other Types of Instruction

Boettcher, Elaine G., Sylvia L. Alderson, and Michael S. Saccucci. "A Comparison of the Effects of Computer-Assisted Instruction versus Printed Instruction on Student Learning in the Cognitive Categories of Knowledge and Application." Journal of Computer-Based Instruction 8 (August 1981): 13-17.

Eighty-three nursing students who were enrolled in an adult psychiatric-mental health nursing course were randomly assigned to either a group using CAI or to one using printed program instruction. Pre-tests, posttests, and retention exams were given to students in two areas: knowledge, and applications. Posttests were given four weeks after instruction began, and retention exams were given 11 weeks after instruction began. Two lessons were given to each group, one giving information concerning psychopharmalogical nursing, and the second lesson emphasizing the use of the nursing process in psychopharmalogical nursing.

In this study, no significant differences were found between groups. Both groups gained in both cognitive areas, followed by a moderate, but significant drop on the retention tests. CAI students had more favorable attitudes toward the type of instruction than did the non-CAI group who received printed instruction.

McDermott, Paul A., and Marley W. Watkins. "Computerized vs. Conventional Remedial Instruction for Learning-Disabled Pupils." Journal of Special Education 17 (Spring 1983): 81-88.

To determine the effectiveness of CAI over conventional remedial methods, 250 learning-disabled elementary children were randomly assigned to either a Mathematics CAI experimental group, a Spelling CAI group, or a conventional instruction control group.

Prior to receiving instruction, students' math and spelling skills were evaluated using standardized achievement tests, and levels of intelligence were measured using an intelligence test. Experimental instruction was given individually through multilevel-multifunctional programs.

The results of the tests showed no significant differences between groups. Based on the results, the authors suggest that the two methods may be substituted for one another. CAI programs could be assigned to students who have motivational deficits. Also, CAI, combined with conventional remedial instruction, may be very useful in helping the disabled learner.

Computer Literacy

Steele, Kathleen J., Michael J. Battista, and Gerald E. Krockover. "The Effects of Microcomputer-Assisted Instruction on the Computer Literacy of Fifth Grade Students." Journal of Educational Research 76 (May-June 1983): 298-301.

To assess the effect of CAI on computer literacy, 86 5th grade students were participants in a study using a CAI mathematics drill and practice program (51 students), and a math drill and practice kit (35 students). In addition to the regular mathematics period, students from both groups received ten minutes of extra instruction two days each week for the entire school year.

A computer literacy test, which measured affective and cognitive knowledge students had concerning computers, was given at the beginning and end of the school year.

The results of the study indicated that by using CAI, student fears and anxieties about the computer were reduced. In addition, students became more aware of computer uses in society, as well as gaining more knowledge of computer terminology and hardware. No significant differences in mathematical achievement was found between groups.

Skills

Bass, George M., and Harvey W. Perkins. "Teaching Critical Thinking Skills with CAI." Electronic Learning 4 (October 1984): 32, 34, 96.

A nine week course incorporating CAI was designed to help students learn four critical thinking skills: verbal analogies, inductive/deductive reasoning, logical reasoning, and work problem analysis. Five classes were offered each quarter to 7th grade students in three middle schools. During the first two quarters, student improvement was assessed using teacher observation, researcher observation, interviews with the students, and pre- and posttests. Results of this formative evaluation indicated that students did increase their critical thinking skills.

A more formal design was used to compare the results of the 3rd and 4th quarters, in which 3rd quarter classes were the experimental group, and 4th quarter classes were the control group. Using standardized tests, measurable gains were found in the verbal analogies skill area for students in the CAI group. This group also made measurable gains in inductive/deductive reasoning. No gains were found between groups in the skills of logical reasoning or word problem analysis.

Sadowski, Barbara R. "Research Notes: Critical Thinking and CAI." Journal of Computers in Mathematics and Science Teaching 4 (Winter 1984-85): 12-13.

Sadowski reviews three research studies on critical thinking and computerized instruction. The first study by Bass and Perkins (1984) involved 7th graders using CAI to improve critical thinking skills. Although vague, results indicated "measurable gains" in verb analogies skills and inductive/deductive reasoning skills among students in the experimental group.

In L. E. Wood's study (1980), a modified version of the game BAGELS was presented to college students. The program provides information to play the game, analyzes responses, and gives corrective feedback, if necessary. Corrective feedback was believed to improved logical thinking skills. Both experimental and control groups were given pre- and posttests to measure levels of critical thinking skills. The experimental group showed a significant gain from pre- to posttest; the control group did not.

A third study by Sadowski (1984) used Woods' 1980 experiment with 5th, 7th, and 12th graders. The 12th graders had similar results as the students in the 1980 Wood study, but the younger students in the Sadowski study were not able to utilize all the information provided by the feedback from the program.

Gadzella, Bernadette M. "Computer-Assisted Instruction on Study Skills." Journal of Experimental Education 50 (Spring 1982): 122-126.

The purpose of this study was to investigate the effectiveness of a CAI study skills program on students' behaviors and attitudes. One hundred fifty-five undergraduate psychology students at a Texas university volunteered to participate in the project. A seven scale, 100 item, self-reporting inventory, designed to measure students' behaviors related to study habits and attitudes, was given to both experimental and control groups on three different occasions during the semester. Subjects in the CAI group completed one CAI study skill module per week for a period of 13 weeks. The control group had no study skills instruction.

Results showed that the CAI group differed significantly on only one scale--the Teacher Approval scale. This finding implied that those in the CAI group had higher impressions of their teachers during the semester than did those in the control group. Also, the CAI group scored significantly higher on the study skills inventory at the end of the semester. For the control group, overall changes from the beginning to the end of the semester on all scales were significant and reflected a downward shift.

Gadzella, Bernadette M. "Research Brief: Study Skills Presented Through Computer-Assisted Instruction to High School Students." Texas Tech Journal of Education 12 (Winter 1985): 47-50.

Gadzella reports the findings of two of her studies in which CAI was used to teach study skills to high school students. In the first study, 56 students in two advanced English classes were given a study skills pre-test, and were randomly assigned to experimental and control groups. Over a four month period, the CAI group completed ten CAI modules related to basic study skills such as time management and note taking. On the posttest given to both groups, the CAI group scored significantly higher than the control group.

The second study involved 57 high school students enrolled in two computer mathematics classes and an algebra class. In addition to study skills pre- and posttests, participants were also given a pre- and posttest self-concept scale. Students' grade point averages were provided by the school. Results showed that the CAI group gained significantly more in study skills, seniors gained more than juniors, and high achievers (GPA 2.8 or above) gained more than low achievers (GPA 2.7 or below). GPA did not correlate significantly with the total self-concept score.

Zsiray, Stephen W. Jr. "A Comparison of Three Instructional Approaches in Teaching the Use of the Abridged Reader's Guide to Periodical Literature." Journal of Educational Technology Systems 12 (1983-84): 241-147

Three instructional delivery systems--microcomputer-based courseware, lecture, and independent reading--were compared for effectiveness in the teaching of library media information retrieval skills. Two hundred 8th grade English students were randomly assigned to one of three groups, each using a different instructional delivery system. One unit of instruction, The Introduction to the Abridged Reader's Guide was given to all three groups.

In the lecture group, the library specialist presented the instruction in 45 minutes. Those in the independent reading group were given a pamphlet which described the Abridged Reader's Guide. Students read the contents and did exercises to demonstrate that they understood what they had read. Completion time for independent reading was about 25 minutes. The computer-courseware group used a program which presented information and asked questions on that information. Average completion time was 25 minutes. Posttests were given to each group.

Results indicated that instructional effectiveness was identical for the computer-based courseware and the lecture approach. Both groups were statistically more effective than the independent reading group, who did not receive feedback.

An important finding is in reference to time needed to complete the lesson. More efficient use of time was realized in the microcomputer-based group (25 minutes) compared to the lecture group (45 minutes).

On Personal Growth and Development

Socialization

Clements, Douglas H., and Bonnie K. Nastasi. "Effects of Computer Environments on Social-Emotional Development: LOGO and Computer-Assisted Instruction." Computers in the School 2 (Summer-Fall 1985): 11-31.

Clements and Nastasi review research concerning six elements of social-emotional development: 1) initiation and participation, 2) social problem-solving, 3) social sensitivity, 4) compliance, 5) effectance motivation, and 6) self-concept.

In addition to reviewing research, the authors conducted a study to investigate the effects of two types of computer environments, CAI and LOGO, on the six elements of social-emotional development.

Twenty-four 1st graders and 24 3rd graders were randomly assigned to either a LOGO or CAI group. There were two LOGO and two CAI groups at each grade level. Each group met twice a week for 45 minutes for a total of 14 weeks.

The CAI groups worked with reading and arithmetic drill and tutorial programs, while the LOGO groups learned to use the turtle to draw, and also learned to develop complex programs.

After 14 weeks of training, students were observed in three situations: one on the computer, and two off the computer. Off-computer tasks were done by students working in pairs.

Findings of the study indicated that there were no increases in initiation and participation, or social sensitivity. There was a marked increase in social problem-solving for both groups. Compliance increased when students were working on the computer, but did not carry over to the off-computer tasks. Concerning the element of effectance motivation, students using LOGO invented more rules and were more self-directed on and off the computer than students using CAI. In the area of self-concept, CAI 1st graders were found to seek teacher approval more often than the LOGO group, especially in the off-computer situations. This may suggest that CAI, for 1st graders, may generate dependency behaviors.

In summary, there seems to be no ill effects on social or cooperative activities because of the use of the computer, and it may be likely that positive social interactions are enhanced.

Diem, Richard A. "A Study of Children's Attitudes and Reactions to the New Technology," Social Education 49 (April 1985): 318-320.

One-hundred fifty-one children, ages 8-12, enrolled in a computer day camp, were participants in a study designed to examine students' interactive social responses to computers. Activities at the day camp were divided between lessons on computer history, field trips, and hands-on computer-related activities.

Two methods, observation and use of a questionnaire, were employed to assess social behavior.

Based on observations, four main behavior patterns emerged: 1) Students had not considered the social implications of using another's information or data. Nor had they considered the right to privacy. 2) If infringements of their right to privacy occurred, they demanded harsh penalties for the wrong-doer. 3) Students tended to work in groups to solve problems rather than trying to solve problems alone. 4) Most students, because of previous computer experience with game-type settings, expected some kind of reward upon completion of a computer task. All of the aforementioned findings were supported by the findings obtained from the questionnaire.

Feldman, David H., and Pauline S. Sears. "Effects of Computer Assisted Instruction on Children's Behavior." Educational Technology 10 (March 1970): 11-14.

The aim of this study was to determine if changes in children's classroom behavior were attributable to a school year of CAI.

Forty-five 1st grade children from low-income families received either a 35-40 minute CAI reading or mathematics program for a period of seven to nine months. Twenty-seven 1st grade children received regular instruction in reading and math. Two major categories, academic behavior and social behavior, were assessed using a modified version of a Behavior Survey Instrument.

Findings indicated that children using CAI slightly increased their academic behavior during the year, while children's academic behavior in non-CAI groups remained stable. The increase in academic behavior correlated positively with achievement, while social behavior correlated negatively. It was also found that CAI students decreased social behavior in the Spring while non-CAI stucents increased social behavior.

Swigger, Kathleen M., and Boyd Keith Swigger. "Social Patterns and Computer Use Among Preschool Children." AEDS Journal 17 (Spring 1984): 35-41.

This study examined the ways in which preschool children interact as they learn with a set of CAI programs. Forty-four children, aged 3 to 5, were sampled. Two types of CAI programs were introduced to the children. Type I consisted of drill and practice programs which introduced the children to pre-reading skills. Type II programs were those requiring problem-solving skills. The children's selections of programs and their time on the computer were noted and recorded during a three-week period. No child was forced to use the computer. Use was strictly through choice.

During the three-week period, there was a high interest in using the computer. Many children worked in pairs or small groups at the computer. No child used the computer completely by himself.

Cliques were found to have developed in respect to computer use. Upon conferring with the nursery school teacher, it was found that the groupings, both major and minor, were similar to the already established play groups. Thus, in this instance, the presence of the computer did not disrupt the social groups of the children.

Self-Esteem

Dalton, David W., and Michael J. Hannafin. "Examining the Effects of Varied Computer-Based Reinforcement on Self-Esteem and Achievement: An Exploratory Study." AEDS Journal 18 (Spring 1985): 172-182.

Forty-four 8th grade remedial mathematics students were given three sets of a basic CAI program consisting of ten randomly generated multiplication fact drill and practice problems. Prior to the CAI program, each student had been given a Likert-type self-esteem questionnaire which consisted of questions concerning general self-esteem, mathematics related self-esteem, and self-esteem related to using the computer.

Students were randomly assigned to one of four treatment groups in which: 1) the computer gave only the correct response; 2) the computer gave the correct response plus reinforcement for correct user response; 3) the computer gave the correct response plus negative reinforcement for any incorrect user response; 4) the computer gave the correct response plus positive reinforcement for correct user response and negative reinforcement for incorrect user response.

After using the CAI program for two instructional periods of 90 minutes, it was found that there were no significant differences in self-esteem or achievement among the four treatment groups.

Attitudes

Cavin, Claudia S., E.D. Cavin, and J.J. Lagowskil. "The Effect of Computer-Assisted Instruction on the Attitudes of College Students Toward Computers and Chemistry." Journal of Research in Science Teaching 18 (July 1981): 329-333.

The purposes of this study were threefold: to see whether college students' attitudes toward the computer and toward chemistry can be affected by the use of CAI, and to determine if there are any differences in attitudes for students of different sexes.

Sixty-two members of a non-science majors' chemistry course were randomly assigned to a CAI group or a non-CAI group. Each group was assigned a series of lessons to do outside class during a five-week period. The lessons for both groups were not equivalent. A ten-statement Likert scale was given at the beginning and the end of the five-week period.

Attitudes toward the computer improved for the CAI group, but did not improve for the control group. Much of this increase is due to the attitude of the females in the CAI group. The interactive and nonthreatening aspects of the computer may have produced this reaction among women.

Attitudes of the CAI group toward the subject matter did not improve significantly, possibly due to the shortness of the CAI usage.

Disruptive Behavior

Jamison, Robert N., and Keith F. Lovatt. "Classroom Delinquency, Achievement, and Computer-Assisted Instruction." Journal of Computer-Based Instruction 9 (Spring 1983): 145-147.

This study examined the effects of a CAI course on learning between extreme groups identified as being the best and worst behaved, and the best and worst achievers among 120 English 8th graders.

A CAI program on respiration was given to 54 boys for a period of six weeks. In addition to CAI, students received teacher-directed demonstrations, and tape/slide presentations. Pre- and posttests were given to measure general science knowledge. A shortened version of an intelligence test was also given.

Results indicated that all students improved on the posttest. The best achiever group scored significantly better than the worst achiever group. The worst behaved group, who had lower IQ scores, had a higher rate of improvement than did the best behaved group. Neither one of the groups scored as well as the best achievers group, but did score higher than the worst achievers group. Thus it seems that CAI is most beneficial to the worst behaved group, who gained as much from the course as the best behaved group, and the high achievers, who improved most significantly.

ADVANTAGES OF COMPUTER-ASSISTED INSTRUCTION

Bright, George W. "Explaining the Efficiency of Computer Assisted Instruction." AEDS Journal 16 (Spring 1983): 144- 152.

Bright discusses the CAI phenomenon--equal learning in less time. This phenomenon has important ramifications. For teachers, efficiency in instruction for even a few topics would allow either more time to devote to complex topics or more topics could be taught.

Of the few studies that have measured this phenomenon, most have indicated that CAI does save learning time for students in high school and college. Only one of the studies measured this phenomenon with younger students (1st through 3rd grades) with results showing a saving of learning time.

One reason Bright gives for the CAI phenomenon is related to the time-on-task hypothesis. CAI programs have the potential to keep students actively engaged, and therefore increase students' success rates.

The amount of engaged time can be increased by increasing the motivation of the student. A student's success rate can be increased through careful matching of the CAI program to the student's skill level.

Bengfort, Anne D. "Micros for Reading, Spelling, and Self-Esteem." Journal of Reading 26 (April 1983): 638-639.

Bengfort describes a reading and spelling CAI program that she has established for use with students in her high school reading lab. She indicated that CAI in this situation has three important advantages. First, self-esteem is enhanced because the students feel proud about their ability to use the computer. Second, motivation is increased because students are able to succeed using CAI. Third, the use of the computer offers a break in routine.

Harrod, Norma, and Marilyn Ruggles. "Computer Assisted Instruction: An Educational Tool." Focus on Exceptional Children 16 (September 1983): 1-8.

Harrod and Ruggles assure teachers that CAI will not replace them, but will instead enhance education by opening up opportunities for extended learning.

Computer literacy and computer-assisted instruction are defined. Also the seven different modes of CAI are identified and discussed. At this writing, the drill and practice mode was used most often in schools using CAI.

Harrod and Ruggles emphasized that CAI can be a great labor and time saving device for the teacher in that there is more time to work with the student or with small groups.

The authors also emphasize the necessity for teachers to be computer literate, and to have good attitudes toward computer use in the schools.

Rupley, William H., and Patricia Chevrette. "Computer-Assisted Reading Instruction: A Promising Tool for Enhancing Teacher Effectiveness." Reading World 22 (March 1983): 236-240.

The results of three CAI reading studies taking place in the early 1970's were reviewed. Although the age of the participants differed greatly among the three studies, marked improvement in reading resulted in all three studies.

The authors attribute the improvement in reading achievement to several factors: 1) CAI provides individualized instruction with immediate feedback. 2) The high rate of success motivates the student and develops positive attitudes about himself and the learning experience. 3) Students are more actively engaged in the task than if they were working at their seats. Thus, more time-on-task. Research has indicated that achievement can be improved considerably by increasing the time spent on learning tasks (Brophy, 1979). Thus, CAI can be a valuable tool that can help to increase achievement in reading.

Ryba, Kenneth A., and James W. Chapman. "Toward Improving Learning Strategies and Personal Adjustment with Computers." The Computing Teacher 11 (August 1983): 48-53.

Ryba and Chapman, who work with mentally retarded students, discuss several advantages of computers and CAI. Their beliefs are based on observation, interviews, review of research, and CAI projects now in progress.

Through the use of computer games and simulations, mentally retarded students develop new skills such as planning, sequencing left to right, and increasing motor speed and coordination. Also, students unresponsive to psychological testing can demonstrate, through computer usage, a higher functioning level than intelligence tests could indicate.

Another advantage is that CAI programs provide students with the opportunity to evaluate their own progress. A fourth advantage is that of affording them the opportunity to control their environment. Although it is debated whether computers actually allow the user to be in control, students believe that they are in control. Thus they may gain an increased sense of achievement and self-worth, which can produce more independent behavior.

Other advantages noted are increase in attendance, high levels of "on task" behaviors, and an increase in social problem-solving skills.

Walker, Decker F. "Reflections on the Educational Potential and Limitations of Microcomputers." Phi Delta Kappan 65 (October 1983): 103-107.

Walker lists and discusses seven main ways that microcomputers can contribute to education, and seven limitations of micros. The potentials of microcomputer use are: 1) more active learning, 2) more varied sensory and conceptual modes, 3) learning with less mental drudgery, 4) learning nearer the speed of thought, 5) individually tailored learning, 6) independent learning, and 7) better aids to abstraction.

The following problems are the most severe limitations of today's microcomputers: 1) Microcomputers can supplement but not replace traditional education. 2) Microcomputers are hard to use, and teachers are ill-prepared to use them. 3) Because there are so many new products and systems, and because there is so little standardization, long term planning is impossible. 4) Good programs are scarce. 5) Nobody yet understands how to use computers well for education. 6) Not all subjects lend themselves to computer teaching such as literature and the arts. 7) Computers will not solve current school problems such as racial imbalance, and inequities in funding.

LIMITATIONS IN USING COMPUTER-ASSISTED INSTRUCTION

Holmes, Glyn. "The Computer and Limitations." Foreign Language Annals 17 (September 1984): 413-414.

Holmes indicates that in the field of foreign language, computers have two major limitations. The first involves that of comprehension skills. Due to the size of the microcomputer screen, it is very difficult to present text all at one time. The text is presented segmentally, decreasing the student's visual continuity, and possibly negatively affecting comprehension.

The second limitation focuses on listening skills. Although some computer systems have the ability to deliver the spoken word via speech synthesizers, for the most part these synthesizers are too crude for language study. Therefore, other media, such as audiotapes and audiodiscs, need to be lined to the computer. These media may not be feasible alternatives.

Holmes emphasizes that the use of computers in foreign language, especially with respect to the teaching of comprehension and listening skills, should be limited. He maintains that many reading and listening activities are best performed by media other than the computer.

Thompson, Mark E. "Beyond the Computer: Reading as a Process of Intellectual Development." Computers, Reading, and Language Arts 2 (Winter 1984-85): 13-15, 43.

Thompson questions the effectiveness of CAI, especially in the area of reading. He contends that actual reading develops reading skills, and also increases motivation for reading. Computer technology may help the student learn the skills necessary to read, but cannot instill in him the desire to read. According to research, active adult readers are those who have had parents who read to them, and were themselves active readers. Thompson is also concerned that computers may be too restrictive, fostering mechanical patterns of thought rather than creative or independent thought. He contends that a computer program cannot provide the intellectual stimulation found in classroom interaction.

Based on these beliefs, Thompson cautions that CAI may be useful to relieve teachers from doing routine tasks, but if computers are substituted for teacher interaction, student intellectual development may be hindered.

Zaharias, Jane Ann. "Microcomputers in the Language Arts Classroom: Promises and Pitfalls." Language Arts 60 (November-December 1983): 990-995.

Instructional uses of the microcomputer fall into three categories: 1) computer-assisted instruction, 2) information processing, and 3) computer-managed instruction. Zaharias discusses the attributes and limitations of each of these categories as it relates to language arts instruction.

In the category of CAI, Zaharias emphasizes that software is of poor quality, and suggests that educators take a lead in designing good educational software. She also emphasizes the use of tutorials and text analysis programs rather then drill and practice programs, which duplicate the role of workbooks and skill kits.

For the language arts, word processors may play an important role in the instruction of writing. However, this type of computer use requires a great amount of time and space on peripheral storage devices. Many schools do not have the resources to make the programs available to all who would want to use it.

The third category, computer-managed instruction, can generate tests and chart student progress.

Those factors which limit the usefulness of the computer are the visual presentations of the software. Extensive use of CAI may impede a student's oral development as well as his ability to interpret and produce written language. It is feared that instead of integrating the elements of speaking, listening, reading, and writing, software programs, in fact, fragment language arts instruction.

Hodes, C. L. "Relative Effectiveness of Corrective and Non-corrective Feedback in Computer Assisted Instruction on Learning and Achievement." Journal of Educational Technology Systems 13 (1984-85): 249-254.

Designers of computer software maintain that providing corrective, nonthreatening feedback will enhance learning. The purpose of this study was to determine if students given corrective computer feedback performed better than those receiving non-corrective computer feedback.

In October 1983, 41 9th and 10th grade students were divided into two groups. Each group received the same computer program on metric conversion written by the author. One group received corrective feedback; the other group, non-corrective feedback. Pre- and posttests were given to both groups.

Posttest scores showed no significant differences between the two groups. However, boys who received corrective feedback scored higher than all other students, and girls who received non-corrective feedback scored significantly lower than boys in both groups.

Pressman, Israel, and Bruce Rosenbloom. "CAI: Its Cost and Its Role." Journal of Educational Technology Systems 12 (1983-84): 183-208.

The costs of a CAI system are becoming more affordable due to several factors. First, with the advent of the microcomputer and its reliable integrated circuits and chip technology, maintenance costs have been reduced. Second, many vendors of hardware and software compete in the CAI market, thus reducing costs. Third, the installation of micros are usually minimal due to the portable features of the units. One area in which costs have not been reduced is in that of user training. Because training costs are expensive, most hardware manufacturers provide these services at extra cost (Frenzel, 1981).

The costs of a CAI system consisting of 15 micros and one master controller were analyzed. This system would be suitable for a small elementary school of 750-1000 students. Costs were spread over a seven year period. Initial costs would be $98,550. If each student (750) used the computer one-half hour per week for 35 weeks, the cost per student hour would be $1.32.

Cost-savings that would offset the expense of a CAI system would include the possibility of decreasing the dropout rates because of increased student interest and motivation.

Spuck, Dennis W. "An Analysis of the Cost-Effectiveness of CAI and Factors Associated with Its Successful Implementation in Higher Education." AEDS Journal 15 (Fall 1981): 10-22.

Spuck discusses five factors which inhibit the use of CAI in higher education, then suggests a strategy for successful change. The five factors which inhibit CAI use are: 1) cost of hardware, 2) cost of courseware, 3) organizational reward structures, 4) negative attitudes of the faculty toward CAI, and 5) resistance of student populations.

Although research indicates that CAI may be an effective instructional tool, the cost-effectiveness of CAI may be a more relevant issue when considering CAI use in higher education. When considering the cost-effectiveness of a CAI system it is not only necessary to estimate the hardware and software costs, but also the number of students who will use the computer and the lifespan of the system and courseware. Based on these considerations, CAI is most likely cost-effective in large introductory classes, and in courses which have relatively stable content material.

The factor of organizational reward structure centers on requiring faculty members to use CAI without allowing them release time for developing software, reviewing available software, or planning for integration of CAI into the course or curriculum. Members are not properly regarded for their contributions to the CAI effort.

Teachers' resistance to CAI comes from a lack of understanding about the potentials and limitations of CAI, a fear of the change computer usage may bring, and the fear that the computer will replace personal interactions with students. Student resistance to CAI was not discussed.

Spuck believes the biggest strategy for change will be that of rewarding faculty members for development of good quality courseware.

Bitter, Gary G., and Shelley J. Davis. "Measuring the Development of Computer Literacy Among Teachers." AEDS Journal 18 (Summer 1985): 243-53.

For students to become computer literate, teachers must first become computer literate. The purpose of this study was to measure the development of computer literacy among teachers. Over an eight semester period, 240 teachers, enrolled in a course on computers in elementary education, were given a computer literacy and awareness assessment at the onset of the course. The test consisted of two parts: attitude and knowledge. The results from each semester were compared to results from prior semesters and then compared by years.

The results of the study indicated that approximately 66% of the teachers felt comfortable about the role of the computer in their daily lives, 50% felt confident in their abilities to use the computer, 94% were interested in learning more about the computer, and 77% experienced interest in owning a computer. The results also indicated that teachers were very well informed about the uses of computers, how computers work, and the capabilities and limitations of computers. They were weakest in programming.

Cicchelli, Terry, and Richard Baecher. "Introducing Microcomputers into the Classroom: A Study of Teachers' Concerns." Journal of Educational Computing Research 11 (1985): 55-65.

A questionnaire, developed to assess the Stages of Concern for an innovation, was given to 78 teachers (47 high school, 7 junior high, and 24 elementary). The seven stages of concern are divided into two main groups: those concerns which focus on the person's abilities to use and implement computers in education, and those concerns that center on the impact of the computer on the student.

The results indicated that, overall, the teachers questioned were aware of and concerned about the implementation of computers, and were eager to learn more about them. They were not overly concerned about the management aspect of computers or about the impact computers have on their students.

Other findings showed a large point spread between high school, and jr. high and elementary teachers concerning management. High schools generally have computers in labs, and thus management worries are not as prevalent as at other levels.

Additional findings indicated that male teachers, especially elementary teachers, were significantly more concerned about the impact of computers on students than were their female colleagues.

Offir, B. "Attitudes of University Instructors and Students Toward Using Computers for Learning: Discrepancies Between Thought and Action." Educational Technology 23 (May 1983): 26-28.

Three different research instruments (observation, questionnaire, and interview) were used to assess students' and teachers' attitudes toward using the computer as an instructional aid. The study involved 12 instructors and 193 physiology students enrolled at London University. Observation was done in 14 physiology lessons. The questionnaire was administered to students at the beginning and end of the academic year. Interviews were conducted at the end of the school year.

The results of the interviews with the instructors indicated that they have a positive attitude toward using the computer as an aid in teaching physiology. They felt that computers gave students a chance to learn individually, and that computers were helpful as a visual aid. However, when given the change to use the computer, not one teacher accepted the offer.

The students' attitudes toward the computer as a helping aid were not favorable. When asked to rank five methods of learning, lecture ranked first, and computer-assisted instruction ranked last.

Clark, Richard E. "Research on Student Thought Processes During Computer-Based Instruction." Journal of Instructional Development 7 (1984): 2-5.

Clark indicates that CBI, with its variables of reinforcement, feedback, practice, and measurable objectives, does not directly contribute to student achievement. Having reviewed research, Clark contends that "instruction influences thinking and in term thinking influences learning and performance."(p. 1)

There are several elements of thinking that influence learning and performance. First, the motivation or effort put into the CBI task depends on the student's beliefs about how difficult it is to learn from computers, how much control he has over the computer, and how fair he considers the computer to be.

Second, when "menus" of study aids are included in programs, students may learn less from the option they choose. High- ability students tend to choose aids because they believe that more support will help them learn more efficiently, where as low-ability students do not use aids when given the choice because of the required effort involved.

Third, highly anxious students tend to learn less from CBI. Anxiety may "interfere with the mental processing 'space' needed for learning..."(p. 5).

Decreased learning may also occur due to the student's beliefs that he does not have the skill necessary to complete the lesson. He then becomes anxious which results in lowered learning (Tobias 1983).

Clark also reviews studies in which hemispheric dominance and brain lateralization were examined, and concludes that there is little evidence concerning thought processes that could be related to CBI design.

In the area of transfer of learning, learning acquired from programs in which computers were in control (drill and practice) does not transfer to novel problems as does learning from programs in which student control is prevalent (simulation).

"Computers' Failure." USA Today, April 1984, 13-14.

This article points out that owning a computer system does not guarantee learning opportunities for children. Sally Pickert, of the Catholic University of America, states that "Children can waste a lot of time on computers if there are untrained teachers and deficient programs" (p. 13). She also maintains that for some children, keyboarding is hard to learn. Another problem that children may have with the computer is being able to take in information that is presented in the abstract form. One other issue relating to computer use is the problem of privacy. Who "owns" information or files? What measures can be taken to prevent tampering or stealing files?

Advantages of computer use for learning are those of individualization, monitoring of student progress, improvement in problem-solving skills, and using simulation programs to make a concept more concrete.

Duncan, Maureen Venti. "Computer Programs and Learning Styles." Computers, Reading, and Language Arts 2 (Winter 1984-85): 13-15.

Two educational computer programs, LOGO and a computer-assisted program in reading, were given to a small group of 1st and 2nd graders with the intent of discovering if students' abilities improved when programs capitalized on their learning styles. Pre- and posttests were given to identify learning styles.

In the LOGO project, five students were exposed to LOGO, a program primarily offering visual learning stimuli. The control group did worksheets in math and reading which used mostly visual stimuli, and little instruction from the teacher.

Another five students participated in the computer reading program which used a speech synthesizer as auditory stimuli. The teacher gave the control group the same lessons. The lessons were given in a one month period.

Results indicated that all students using the LOGO program improved in all three modalities, with the visual modality most improved. However, the visual learners using LOGO did not improve their skills more than the auditory learners in the same group, but did better than the visual learners in the control group.

Students using the speech synthesizer did better than the students reading with the teacher, but the auditory learner in the speech synthesizer group did not do better than the visual learner in the group.

Indirect results noticed were increased verbal expression and more attention paid by the learner to the task at hand.

Hoffman, Jeffrey L., and Keith Waters. "Some Effects of Student Personality on Success with Computer-Assisted Instruction." Educational Technology 22 (March 1982): 20-21.

The purpose of this study was to answer two questions: 1) Do certain personality types complete the CAI learning tasks earlier? 2) Is there any relationship between personality type and dropout rate from the instructional program?

Participants of the study were members of the military who received CAI training on Morse Code in a one-week class at a Naval training center. This study spanned a seven week period, with a total of seven different classes being studied. Records were kept on student progress and failure. In addition to CAI, all students were given a test to assess personality preferences. Four aspects of personalities were examined: 1) Extraversion-Introversion (Is primary focus on people or ideas?), 2) Sensing-Intuition (Does one perceive by using senses or intuition, imagination, and inspiration?), 3) Thinking-Feeling (Is person more often logical and analytical or does he rely on empathy, feelings, or sensitivity?), 4) Judging-Perceptive (Is person primarily concerned with making systematic, orderly judgements about the world or with experiencing, understanding, and accepting it?).

Results indicated that Sensing type personalities completed the CAI program much sooner than the intuitive (N) types. Extraverted perceptive (EP) types had a much higher (53%) dropout rate than did the other types.

Learning favored those who could concentrate quietly, pay attention to details, memorize facts, and stay with a single task until completion (Sensing type). According to Lawrence (1979) those who dropped out tend to like variety and action, prefer theory to application, pay attention to the broad picture, like group projects and team competition, and create new ways of doing things.

SUGGESTIONS FOR MORE EFFECTIVE CAI USE

Salisbury, David F. "How to Decide When and Where to Use Microcomputers for Instruction." Educational Technology 11 (March 1984): 22-24.

Often, microcomputers are purchased by schools to help alleviate instructional problems, without ever really knowing what those instructional problems are. Salisbury presents a three phase questioning process which should be employed when deciding when and where to use microcomputers for instruction. The three questions to be answered are: 1) What student performance gap exists? 2) What functions need to be performed in order to close the student performance gap? 3) What alternatives are available to perform the needed functions given time, money, and human resources?

To answer the question concerning performance gaps, it is necessary to determine how students are presently performing and how they should be performing. The difference between the two is the "gap."

In relation to functions, Salisbury cites the instructional design model of Gagne's Events of Instruction (Gagne 1977, Gagne and Biggs, 1979). The nine events in this model are: 1) gain attention, 2) inform the learner of the objective, 3) stimulate recall of prerequisite learning, 4) present the stimulus material, 5) provide learning guidance, 6) elicit the performance, 7) provide feedback, 8) assess the performance, and 9) enhance retention and transfer.

The third question involving alternatives requires a close look at all alternatives. Microcomputers should only be used if they can better perform the necessary task better than some other medium.

Bear, George C. "Microcomputers and School Effectiveness." Educational Technology 24 (January 1984): 11-15

Although research has indicated that CAI is effective in improving student learning, Bear maintains these findings cannot be generalized to a typical school environment having one computer per 50 or more students. He suggests that until we learn from research the best ways to use computers, elements of teacher effectiveness should be applied to computer use.

Effective teachers have the following characteristics: 1) Effective teachers allow more time for academic tasks than do ineffective teachers. 2) To increase academic learning, teachers employ efficient group management procedures and provide a good learning environment. 3) Effective teachers match the levels of the assigned tasks to the student's achievement levels. 4) They teach to mastery by providing drill-and-practice, monitoring student progress, and providing feedback and remedial instruction. 5) Effective teachers do not expect students to master their assignments on their own. Usually, skills are taught by the teacher before the student begins independent practice.

With respect to computers and CAI, learning time can be increased, CAI programs can be selected that provide the difficulty levels needed for each student, and which provide drill-and-practice, constant feedback, and continual monitoring of student progress. Research indicates that most CAI programs are best used as a supplement to regular instruction, not as a totally independent learning activity. Finally, computer usage should be scheduled so that there are few disruptions in the classroom, and so that students can use the computer with little teacher assistance.

Fisher, Glenn. "Where CAI is Effective: A Summary of the Research." Electronic Learning 3 (November-December 1983): 82-84.

Based on five different CAI research reviews, Fisher summarizes the effects of CAI on learning. According to the reviews, CAI is most effective at raising achievement for low-achieving and high-achieving students. This implies that CAI should be used for specific groups--not the entire student population. CAI is also consistently effective when integrated with classroom instruction, and when used in particular areas, especially science, math, and foreign languages.

In addition to the effects of CAI on academic achievement, affective results were reported. These include positive student attitudes, improved attendance, increased motivation, and lengthened attention span. Some students began to feel more "in control" of events, and became more independent. Implications are that CAI could be used to help change anti-social behavior and outlooks.

Another factor which contributes to the effectiveness of CAI is the use of quality software that is appropriate for the student and the task at hand.

Becker, Henry J. "School Uses of Microcomputers: Report #6 from a National Survey." Journal of Computers in Mathematics and Science Teaching 4 (Winter 1984-85): 42-49.

The focus of this survey was on how teachers organize classrooms when they have more students than microcomputers available to them. Data from 1,082 microcomputer-using schools was examined.

At the elementary and secondary levels students spent over one-half of their computer time working strictly alone or with help from other students. The remainder of the time was divided between working in pairs and groups. However, at the junior high level, paired activity was used more often than individual activity or grouping.

At all levels, the primary activity of students who were waiting to use the computer was that of seatwork, although jr. high students in programming classes did more watching of computer users than they did seatwork. Whole-class lecture during in-class computer use was seldom used.

Other results indicated that women teachers have students work in pairs at the computer more often than male teachers, and more experienced teachers have students work on small group projects during waiting time while less experienced teachers have students watch or do seatwork.

Nicolay, William L. "Group Learning and the Computer: The Teacher Brings An Apple for the Students." American Annals of the Deaf 128 (September 1983): 521-24.

Nicolay, a teacher of the hearing-impaired at a Washington elementary school, encourages the use of the computer as an instructional aid in a group setting rather than using it only as an aid for individualized drill and practice or tutorials. He bases this type of CAI use on the research of Denhan and Leiberman (1980) who contend that student engagement rates are higher in group settings and when students are more actively involved in academic interaction with the teacher. Engagement rates are measured by the active participation of the student in the learning process (Bloom 1976), and by the continuous monitoring of student responses by the teacher (Bloom 1980). Teachers can thus determine the quality of the instruction given and the extent to which the students have the needed skills for new learning tasks.

With these ideas in mind, Nicolay designed several instructional programs in mathematics, reading, and language arts. The computer became an extension of his creativity in helping to present instruction to his group of students.

Dugdale, Sharon. "What's the Student Doing?--A Crucial Aspect of Instructional Design." Educational Leadership 39 (February 1982): 384-385.

With the use of CAI on the increase in the schools, it is important that teachers consider what the student actually does when he uses a particular software program. It is necessary to strip the program back to the actions that the student must make, and to the information to which he must attend. Although the user must know what to do to use the program, it is imperative that what he does is a result of his thinking. An example would be a program that allows the student to explore the placement of rational numbers on a number line. Balloons are displayed on a segment of a vertical number line--perhaps from numbers 2 to 3. The user has to shoot a dart at a balloon on the number line by typing in a number to specify a position on the number line, such as 2-1/4. The program continues until all of the balloons have been hit. In order to hit the balloons, the student has to apply mathematical concepts he has already learned. The student's performance is continually monitored, and difficulty levels are adjusted to a challenging but comfortable level for each student.

Kontos, George. "Cost-Effective, Teacher-Made, Quality CAI--A Fallacy." Electronic Education 3 (May-June 1984): 23,35.

Due to the vast amount of poor quality software on the market, many experts in the teacher-author field encourage educators to design software. Kontos warns that this suggestion is based on faulty thinking. Educators who develop software need extensive training and financial backing, which is often not available. In addition, the development of software requires the developer to willingly spend large amounts of time on the project. This is the largest problem that a teacher-author faces.

Kontos suggests that those educators who willingly choose to develop courseware, receive extensive training, be given uninterrupted free time, and keep themselves abreast of all new developments and techniques via seminars, workshops, recent publications, and information/research centers.

Kontos also suggests that a more practical way to develop good quality software is through teamwork. Computer professionals and educators can work together to achieve quality software. The future of computers in education should not rely on educators alone, nor on the computer industry alone. It should be a team effort.

Placek, Robert W. "Choosing the Best Software For Your Class." Music Educator's Journal 72 (September 1985): 49-53.

Placek relates the principles upon which CAI was originally based. Teachers and specialists in various teaching areas were to control the content and design of CAI materials. CAI was intended to instruct and not to amuse. CAI lessons were to be evaluated in terms of their ability to achieve instructional objectives. The unique capabilities of the computer were to be utilized. CAI was to provide individualized instruction. And finally, CAI systems were to function as a live teacher would by providing responses to student input.

These principles of CAI should still be prevalent in today's CAI program. When evaluating software, several factors should be considered: 1) matching the program with the user's needs, 2) the extent and the comprehensiveness of the subject matter covered, 3) the program's branching capabilities, and 4) the effect of "sound effects" on the user and the classroom.

Placek also discusses various music software programs that are especially good.

Barbour, Andrew, and others, eds. "Computing in America's Classrooms 1984." Electronic Learning 4 (October 1984): 39-41, 100.

To assess what is happening in educational computing, telephone interviews were conducted with staffers at all fifty state education departments. Four trends were discovered: 1) Much emphasis is being placed on integrating the computer into the curriculum rather than providing single courses. 2) In computer literacy courses, there is less emphasis on programming and more emphasis on applications of computers. Programming is being offered as a separate computer science course. 3) Teacher training programs, both in-service and pre-service, are on the upswing. 4) Twenty states now mandate the teaching of computer literacy in the schools. Half of these states set up the requirements for computer education, while the other half allow the local schools to implement programs using state-developed guidelines.

Pipho, Chris. "The Computer Literacy Dilemma in the Public Schools." Educational Horizons 63 (Spring 1985): 100- 103.

The meaning of computer literacy is in a continual process of change. At one time, programming was the main emphasis of computer literacy. Today, it has shifted from programming to ease of use.

With almost half of the states mandating computer literacy as a requirement for high school graduation, it is necessary that trained teachers be available to teach this concept. Many agree that teacher training is the key to the implementation of computers in the school.

Integration into the total school program can be facilitated in several ways: 1) All teachers should have access to at least one computer with software that is useful. 2) Allow teachers to use the computer on weekends or nights. 3) Allow teachers to become familiar with and evaluate software. 4) Use the computer for report cards, class lists, etc. 5) Allow students to use the computers on weekends or at night. 6) Integrate the computer into the curriculum as soon as possible. 7) Inform parents of computer uses and involve them in the computer literacy effort.

Parker, Walter. "In-service Computer Training Puts the Ox Before the Plow." The American School Board Journal 172 (March 1985): 42,72.

Schools are attempting to educate their teachers in the uses of the microcomputers through in-service programs. Unfortunately, many are going about it in the wrong way. Course content that consists of an overview of computer hardware, simple programming, and a review of available software may give teachers a vague notion of how to use microcomputers, but no idea as to how to use them in the classroom to help students achieve goals.

Parker suggests three steps in planning an in-service program: 1) Focus on existing curriculum goals. 2) Analyze the objectives students have trouble mastering. 3) Focus on how to use the computer to ease areas of trouble identified in step 2.

This type of in-service program--one based on meeting curriculum goals while it trains teachers in how to use computers--is money spent directly on increasing student achievement.

Tauber, Robert T. "Microcomputers in the Classroom--What Are the Elements of Inservice Workshops for Teachers?" NASSP Bulletin 69 (April 1985): 9-14.

Some educators see microcomputers as belonging to the realms of science, mathematics, and computer science. This attitude can be transferred to students, who will then enter the work force basically illiterate in the technology of microcomputers.

Tauber suggests that an in-service six hour workshop for teachers can help to eliminate this problem. The objectives of the workshop are: 1) to provide general knowledge of the functions of the microcomputer; 2) to develop specific skills necessary to operate the hardware and software; 3) to assess the impact of microcomputers on today's society; 4) to foster a positive attitude toward microcomputers; and 5) to explore specific ways that educators' knowledge, skill, and attitudes can influence today's high school students.

Tauber emphasizes that in-service training should focus on the examination of software packages that allow the computer to be used as a tool, rather than on programming, which most students and teachers will not use.

Thompson, Ann D. "Helping Preservice Teachers Learn About Computers." Journal of Teacher Education 36 (May-June 1985): 52-54.

Because of the recent emphasis on the use of the computer as a thinking and a learning tool, teacher educators need to expand the types of computer experiences they provide their students. A course to meet this need was designed at Iowa State University.

The course consisted of two one-hour lectures and one two-hour lab session each week for an entire semester. Elements of the course included introductory work on using the hardware and software, reviewing software, programming with the LOGO language, using a word processor, using the computer to manipulate data, and finally working on two time-sharing facilities.

Pre- and posttests were given to students enrolled in the class to measure knowledge of computers and attitudes toward computers. Results indicated that students made knowledge and attitude gains. After the course, students had a higher interest in computers, had less anxiety about using computers, and felt that they had natural ability in working with computers, programming, and the operation of the computer.

SUMMARY

Applications

According to various articles and studies, computer-assisted instruction is used in many different subjects and skills areas, and with students who have varied ages, ability levels, and student characteristics.

At the preschool level, Swigger and Swigger (1984) assessed the effects of CAI on the social development of young students. In this instance, CAI programs focused on the teaching of pre-reading and problem-solving skills.

Much of the research indicated a frequent use of CAI in the elementary school with both average and low achievers. Bradley (1982) initiated word processing programs to help develop students' writing abilities. Saracho (1982) successfully used CAI to raise mathematics and language arts scores of Spanish-speaking children of migrant workers. CAI was also used to increase spelling scores for low achieving first graders (Teague, Wilson, and Teague, 1984).

At the junior high level, CAI was used less frequently than at the elementary school level. Uses at this level included the teaching of remedial mathematics (Dalton and Hannafin, 1985), and the teaching of various skills. Zaharias (1983-84) used a CAI program to teach library skills, and Sadowski (1984-85) and Bass and Perkins (1984) used computer programs to teach critical thinking skills.

Computer-assisted instruction at the high school level was applied most often to the teaching of science (Hodes,

1984-85; Anderson, et al., 1980-81), and remedial reading (Bengfort, 1983; Rupley and Chevrette, 1983; Dowling, 1982). Critical thinking skills were also taught through the use of CAI (Sadowski, 1984-85). Another skill area taught was that of study skills. Bernadette Gadzella (1985) taught these skills via CAI to high school students in English and Mathematics classses.

At the college level, CAI was used infrequently. Most of the CAI use at this level was in the teaching of science (Boettcher, Alderson, and Saccucci, 1981; Cavin, Cavin, and Lagowski, 1981), critical thinking skills (Sadowski, 1984-85), and study skills (Gadzella, 1982).

Although CAI is seldom implemented in adult education, there are some programs being used. Nancy Vaac (1984) described the use of CAI to develop reading and writing skills in adults, while Hoffman and Waters (1982) used CAI to teach Morse Code to military personnel.

Those students at the extremes of the ability spectrum, the gifted and the mentally retarded, have also used CAI to enhance learning. Both William A. Beasley (1985) and Walkington and Babcock (1984) advocate the use of computers and CAI with gifted students. Computer-assisted instruction is used to introduce a new content area, and can, through a simulation program, provide the student a chance to explore the effect of variables upon a given situation (Beasley, 1985).

Ryba and Chapman (1983), who work with mentally retarded children, have found that CAI helps these children develop new skills, and increases motor speed and coordination.

In addition to its uses with varied subject content and student characteristics, CAI has also been applied to the teaching of the physically handicapped, and to students who have behavior problems.

Phyllis Brunken (1984) described a program at the Nebraska School for the Visually Handicapped, which incorporates the use of CAI to teach spelling and reading. With the hearing impaired, William Nicolay (1983) used self-designed CAI programs in group settings rather than in individual settings.

With juvenile delinquents, CAI was used to increase reading levels, to improve mathematices and language arts skills, and, through a high frequency of success, to improve a student's concept of being in control of his life (Dowling, 1982). In the study of Jamison and Lovatt (1983), "worst" and "best" behaved, and "worst" and "best" achievers were studied to see the effects of CAI on achievement. The authors contend that many students who exhibit disruptive behavior are not necessarily poor achievers, but are students who need individual attention, which is not ordinarily available in the regular classroom setting. CAI offers them the individual attention needed. Through CAI, student frustrations are decreased, which in turn, reduce disruptive behavior (Jamison and Lovatt, 1983).

Effects

The second aspect of CAI centers on the effects that it has on students. Most of the research in this area focused on the academic growth and development of the student, which includes achievement and various skills, or on the student's personal growth and development, which involves attitudes, self-esteem, behavior, and socialization.

In the first category, academic growth and development, achievement gains were realized for students in the majority of studies which assessed this effect. Teague, Wilson, and Teague (1984) found that of seven first graders who were low achievers in spelling, six students improved their spelling scores using CAI. One child's scores actually dropped, possibly due to a fear of the computer. Saracho (1982) reported achievement gains for Spanish-speaking students involved in her study. These gains were in the areas of mathematics, reading, and language arts. In a review of two studies, Gerald W. Bracey (1982) reported that CAI students scored better on objective tests in the areas of mathematics, reading, and language arts, than did non CAI students. McCaslin and Stevens (1984) also reported on various studies which found achievement gains for elementary learning-disabled students. In one of the studies reviewed (Chiang, 1978), three-fourths of two hundred handicapped students made positive gains. A meta-analysis by Kulik, Bangert, and Williams (1983), which analyzed the findings of fifty-one studies assessing the effects of CAI, reported that CAI did

produce achievement gains in thirty-nine of the forty-eight studies assessing achievement. Twenty-three studies reported significant gains.

Several studies compared the effects of CAI to those of other types of instruction. Paul McDermott and Marley Watkins (1983) compared CAI to conventional remedial instruction; Boettcher, Alderson, and Saccucci (1981) compared it to printed instruction; and Stephen W. Zsiray Jr. (1983-84) compared CAI to lecture and independent reading. In all three studies, CAI was found to be as equally effective as the other types of instruction, with the exception of independent learning. In this instance, CAI was more effective (Zsiray, 1983-84).

Computer-assisted instruction was also found to be effective in improving students' study skills, library skills, and critical thinking skills. Both Bass and Perkins (1984) and Sadowski (1984-85) reported improvement in critical thinking skills. Bernadette Gadzella (1982, 1985) reported that in three studies she conducted with high school and college students, significant gains in study skills were made with the high school students. College students did improve, but not significantly (Gadzella, 1982).

In the second category, effects of CAI on the student's personal growth and development, there were four main areas in which CAI effects were assessed. Several studies addressed the issue of the effect of CAI on the socialization of the child. Critics of CAI have warned that exposure to

computers over an extended period of time may negatively affect children's classroom behavior, resulting in less successful school performance (Feldman and Sears, 1970). The studies that investigated this issue found that CAI had no ill effects upon the socialization process of the student (Clements and Nastasi, 1985; Diem, 1985; Swigger and Swigger, 1984). In fact, students became more collaborative and cooperative when solving problems (Bracey, 1982; Diem, 1985). However, four of the five studies were not of long duration, ranging from three weeks (Swigger and Swigger, 1984) to fourteen weeks (Clements and Nastasi, 1985). The fifth study (Feldman and Sears, 1970), was conducted over a seven to nine month period. The results of this study indicated that for first grade children using CAI, there was a slight decrease in social behavior at the end of the computerized instruction.

Only one study assessed the effect of CAI on a student's self-esteem. Dalton and Hannafin (1985) assessed the effects of four different CAI treatments on self-esteem and achievement, with the results that there were no significant differences between treatment groups in either area. Several authors have alluded to improvement in self-esteem as an advantage of CAI, but have not really supported their thinking with research (Bengfort, 1983; Rupley and Chevrette, 1983).

A third area of personal growth and development affected by CAI is that of student attitudes. According to findings

in the reviews of Kulik et al. (1980, 1982) and Bracey (1982), students using CAI emerged with more positive attitudes about computers (Bracey, 1982), computer-assisted instruction, and the subject being taught (Kulik, et al., 1980, 1982). In the study done by Cavin, et al. (1981) which assessed attitudes of college students (1981), it was found that attitudes toward the computer improved for the CAI group, but attitudes did not improve toward the subject matter.

A final area in which CAI may affect the student's personal growth and development, is that of classroom behavior. No study could be found that actually studied this possible effect of CAI, but two articles implied that CAI could reduce disruptive classroom behavior. Jamison and Lovatt (1983), in their study which assessed achievement gains for "best" behaved and "worst behaved", and "best" achievers and "worst" achievers, contend that if disruptive students are challenged by use of CAI materials, there will be a reduction in disruptive classroom behavior. Barry Dowling (1982) who reported on the use of CAI in a juvenile delinquent facility in California, supports the thinking of Jamison and Lovatt (1983).

Advantages

According to many authors, CAI has numerous advantages that other types of instruction do not have. Advantages cited most often were those of immediate feedback (Dence, 1980, citing Tait, Hartley, and Anderson, 1974; Forman, 1982;

Rupley and Chevrette, 1983), individualized instruction (Forman, 1982; Rupley and Chevrette, 1983; Walker, 1983), and an increase in social problem-solving skills (Clements and Nastasi, 1985; Diem, 1985; Ryba and Chapman, 1983). Another advantage often cited was that of time-on-task (Bright, 1983; Rupley and Chevrette, 1983; Ryba and Chapman, 1983; Walker, 1983). Research has indicated that achievement can be markedly improved by increasing the time spent on learning tasks (Rupley and Chapman, 1983, citing Brody, 1979). According to these authors, CAI increases the amount of time students spend on a learning task.

Other advantages were discussed by the various authors. For students in a high school reading lab, Anne D. Bengfort (1983) indicates that CAI enhances students' self-esteem, motivates students, and offers a break in routine. Ryba and Chapman (1983) found that CAI used with mentally retarded students allowed the students to develop new skills such as sequencing left to right, increased motor speed and coordination, allowed students to evaluate their own progress, gave them the opportunity to control their own environment, and was helpful in assessing the functioning level of some students who were unresponsive to psychological testing. They also found that there was an increase in attendance.

Decker F. Walker (1983) also listed the advantages of more varied sensory and conceptual modes, learning with less mental drudgery, learning nearer the speed of thought, and

providing better aids to abstraction.

A very important advantage of using CAI involved that of time-savings. Bright (1983) discussed the CAI phenomenon--equal learning in less time. Of the few studies that have measured this phenomenon, most have indicated that CAI does save learning time for students in high school and college (Bright, 1983). These findings were supported by similar findings in the meta-analyses studies of Kulik, et al. (1980, 1982). Compared to conventional instruction (3.5 hours of instructional time per week) computer-assisted instruction time was substantially less (2.25 hours per week)(Kulik, Kulik, and Cohen, 1980). In the other study by Kulik, Bangert, and Williams (1982), savings in time was 39% in one study and 88% in another study. In reviewing the literature concerning CAI, Marie Dence (1980) cited two studies which indicated savings in learning time for CAI students. In Allen's study (1972), a 40% savings in time was realized, and in the Bitzer and Alpert study (1970), a 50-66% savings was indicated.

In addition to helping a student learn in less time, Bright (1983) maintains that the savings in time can allow the teacher more time to devote to complex topics, or to the teaching of more topics. Forman (1982) and Harrod and Ruggles (1983) both agree that a savings in time will allow teachers more time to work with individual students or small groups.

Limitations

For the purpose of this paper, CAI limitations refer to the factors which may temporarily affect the successful use of CAI, as well as those factors which may be a more permanent impediment to CAI use.

Limitations of CAI fall into two categories: those concerning subject area, materials, and costs; and those relating to teachers and students.

In the first category, several authors have discussed limitations of CAI use in a particular curriculum. Glyn Holmes (1984) indicates that in the field of foreign language, computers have two major limitations. The first involves that of comprehension skills. Due to the size of the computer screen, it is very difficult to present an entire text all at one time. Thus, due to the segmented presentation, students may lose visual continuity which can negatively affect comprehension (p. 413). The second involves listening skills. Listening skills cannot be developed easily using CAI, as most computers would require the link-up of a synthesizer, audiodisc, or audiotape for this function. These media may not be feasible alternatives (p. 413). In the area of reading, Thompson (1984) expresses concern that computers and courseware can be too restrictive, fostering mechanical patterns of thought rather than creative and independent thought. Thus, student intellectual development could be hindered (p. 15). Zaharias (1983), who discusses the promises and pitfalls of the computer in the

language arts classroom, holds a similar view. She states that the "extensive use of the microcomputer may, in fact, impede such development (oral development), as well as children's ability to interpret and produce written language" (p. 994). Walker (1983) believes that not all subjects lend themselves to computer teaching such as literature, the arts, mathematical invention, and other aspects of the humanities.

Another limiting factor in using CAI is that of equipment and CAI materials. Many of the authors agree that CAI software has been of very poor quality, and that even those of good quality have been used inappropriately (Zaharias, 1983). Zaharias (1983) lists negative attributes of CAI software: 1) contains factual errors, 2) cannot be modified, 3) has complicated instructions, 4) has too long or too short response times, and 5) is not compatible with all hardware (p. 991). Dence (1982) agrees that materials are poorly constructed, and that many are undocumented. She also notes that there is a diversity of computer languages and hardware systems which limit the use of CAI (p. 43).

A third factor limiting CAI use is that of costs. Several articles addressed this issue. Pressman and Rosenbloom (1983-84) analyzed the use of a microcomputer system in an elementary school, and found that the cost per student hour was $1.32. Forman (1982) estimated the cost of CAI use as $1.00 per student hour. However, this estimate did not include maintenance and courseware costs. Forman also cited Norris (1978) who indicated that traditional

instructional costs have risen at a rate of 13% per year while CAI costs have decreased at a rate of 5% per year. Pressman and Rosenbloom (1983-84) also indicated that CAI costs are coming down due to a saturation of vendors in the hardware and software markets.

In addition to the initial purchase costs and maintenance costs, costs of training teachers to use the system must be considered. According to Pressman and Rosenbloom (1983-84) this is one of the most expensive components of the cost of a CAI system. Regardless of the downward trend of CAI systems costs, there may be many schools which still find the costs outside their school budgets.

The second category of limitations relates to the limitations of teachers and students. A teacher's lack of training in the use of the computer and CAI materials, and poor teacher attitudes can seriously limit the effectiveness of CAI (Forman, 1982). Bitter and Davis (1985) conducted a study to determine if teachers are computer literate. The results indicated that teachers are very well informed about the uses of computers, how computers work, and the capabilities and limitations of computers. However, few teachers are trained in the use of CAI materials. As Sally Pickert states in USA Today (1984) "Children can waste a lot of time on computers if there are untrained teachers and deficient software" (p. 13).

One study (Offir, 1983) assessed students' and teachers' attitudes toward using the computer as an instructional aid. Teachers in this study felt that computers gave students a chance to learn individually, and that computers were helpful as a visual aid. However, when given the chance to use the computer, not one teacher accepted the offer. In this instance, there was a discrepancy in what teachers said and what they did. However, in a study assessing teachers' concerns about the use of microcomputers in the school (Cichelli and Baecher, 1985),the results indicated that teachers were eager to learn more about computers and their uses.

In regard to student limitations, there are several limitations pointed out by various authors. Clark (1984) indicates that three student characteristics may affect the successful use of CAI. First is the student's beliefs about how difficult it is to learn from a computer, how much control he has over the computer, and how fair he considers the computer to be (p. 2). Second is the student's choice of options in a program, which may not help him learn (p. 3). Third is the student's degree of anxiety that he has in using computers and computer programs (p. 4).

In an article in USA Today (1984), Sally Pickert maintains that some children may have a difficult time learning to keyboard, and others may not be able to take in information that is presented in the abstract form.

Duncan (1984-85), in a study examining computer programs and learning styles, found that when computer programs were used with children who had either a visual learning style or an auditory learning style, there were no significant differences in reading skills. This result also held true for learners using a computer with a voice synthesizer. Hoffman and Waters (1982) found that the personality type of the student may affect his success in using CAI materials. Among military personnel, it was found that those who could concentrate quietly, pay attention to details, memorize facts, and stay with a single task until completed, were the most successful learners.

Suggestions for More Effective Use of CAI

There were several authors who made suggestions for more effective use of CAI. Salisbury (1984) maintains that schools should determine students' performance gaps, and then consider which alternatives can be used to close these gaps. Computers should be used only if they can perform a task better than some other method (Salisbury, 1984). Bear (1984) suggests that until we can learn from research the best ways to use computers, elements of teacher-effectiveness should be applied to computer use. He also suggests that computer usage should be scheduled so that there are few interruptions in the classroom, and so that students can use the computer with little teacher assistance (p. 13).

With respect to how CAI is used with the students, Fisher (1983), in a summary of the research, indicated that CAI should be used with specific groups, and not with an entire student population.

Concerning computer use in the classroom, a survey done by Becker (1984-85) found that at the elementary and secondary levels, students spent over one-half of their computer time working in pairs or groups. At the junior high level, paired activity was used more often than group or individual activity. Nicolay (1983), who teaches the hearing impaired, uses the computer as an instructional aid in a group setting rather than using it only for individualized instruction. He bases his practices on the belief that student engagement rates are higher when students are actively involved with the instructor (p. 522).

Another suggestion for increasing CAI effectiveness is that of selecting good software. Two authors discuss how to evaluate software. Dugdale (1982) recommends that teachers evaluating software determine what it is that the student is actually doing when he is working with a CAI program. Considerations listed by Placek (1985) are: 1) match the program with the user's needs, 2) determine the extent and comprehensiveness of the subject matter covered, 3) examine the program's branching capabilities, and 4) consider the effect of "sound effects"on the user and the classroom. A third author, Kontos (1984) suggests that in order to develop

good software, computer professionals and educators should work together.

Final recommendations for the effective use of CAI concern the training of teachers in the use of computers and CAI materials. According to a survey of state education departments by the editors of Electronic Learning (Barbour, et al., 1984), teacher training programs, both in-service and pre-service, are on the upswing. This may be a result of the increased use of computers in the school curriculum, and also to the fact that the teaching of computer literacy has been mandated in twenty states (Barbour, et al., 1984).

In order to help pre-service teachers learn more about computers, a course was designed to meet this need at Iowa State University. After one semester, students enrolled in the class had a higher interest in computers, had less anxiety about using computers, and had made gains in knowledge about the computer (Thompson, 1985).

Two authors suggested ways of conducting in-service workshops for training teachers in the use of the computer and CAI. Parker (1985) advocates a type of in-service program which concentrates on the goals of the curriculum, and on objectives students may have trouble mastering. Tauber (1985) supports a program that emphasizes a general knowledge of the computer, an ability to operate the hardware and software, an ability to assess the impact of computers on today's society, and an examination of software packages.

Pipho (1985) maintains that the school administration can help ease the integration of computers into the school program by allowing teachers and students the use of the computer on weeknights and weekends. Teachers should also be allowed to use and evaluate software, and should use the computer for report cards, class lists, etc. This allows them to become familiar with the computer system (Pipho, 1985).

CONCLUSIONS

Having examined the preceding annotations, we can begin to get answers to some of the questions asked in the introduction of this paper. Listed below and on the following pages are the original questions, and conclusions based on the research of literature pertaining to CAI.

1.) With what age groups, ability levels, and subjects can CAI be used?

According to the various articles and studies, CAI can be used with students of all ages, from preschoolers to adult learners. CAI seems to be most often used at the elementary, jr. high, and senior high levels, with sparse usage at the preschool, college, or adult levels.

Students which use CAI included children of all ability levels, ranging from the mentally retarded to the gifted.

In the literature, CAI was used to teach concepts or supplement instruction in a variety of subjects. In the field of science, CAI was used in general science, biology, chemistry, physiology, and psychopharmacology. In the language arts area, CAI programs were used to teach spelling, reading, and language. Several of the studies used CAI, especially drill-and-practice programs, in mathematics. Still others used CAI to teach study skills, critical thinking skills, and library skills.

Based on these findings, it would seem that CAI can be used as a learning tool in many academic areas, and with

learners of varied ages and ability levels.

2) Is CAI effective in producing achievement gains?

Significant achievement gains were reported in three-fourths of the studies assessing the effect of CAI on achievement. The gains occurred for students of different ages and abilities, and for different subjects.

In the studies not reporting significant achievement gains, CAI, although not producing higher gains, did produce equal gains. In no study was CAI found to be less effective than other instructional modes.

Thus, it would be relatively safe to say that CAI can produce gains in student achievement equalling or surpassing that of most other methods of instruction.

3) Does CAI affect other aspects of student development other than achievement?

In addition to the effect of CAI on student achievement, studies also assessed the effects of CAI on the self-esteem, social behavior, and classroom behavior of the student.

Only one study assessed the effect of CAI on self-esteem (Dalton and Hannafin, 1985). The results of this study showed no change in self-esteem. However, several articles indicated that students' self-esteem had increased after using CAI. These findings were based on teachers' observations in the classroom. Thus, it would seem that no definite conclusions can be drawn as to the effect of CAI on the self-esteem of a student.

With respect to social behavior, the findings of the four studies examining this aspect indicated that CAI has no ill effects. In fact, CAI may enhance positive social interactions. However, it is important to remember that few studies have examined the effect of prolonged use of CAI on the social behavior of the student.

Two authors discussed the effect that CAI has on disruptive classroom behavior. No conclusions about this effect could be formulated.

4) What effect does CAI have on attitudes of students and teachers concerning computers?

With respect to student attitudes, most studies concluded that CAI does improve student attitudes toward the computer, but little evidence has been obtained that CAI develops positive student attitudes toward the subject being taught.

Many authors contend that teachers are still reluctant to use computers in the classroom, probably due to their fear that the computer will replace them, and due to the lack of knowledge they have about computers (Harrod and Ruggles, 1983). However, teachers' attitudes are becoming more favorable as teachers become more exposed to computers in the school. According to Cicchelli and Baecher (1985), teachers are eager to learn more about their computers and their uses.

Based on these findings, it can be concluded that computers and CAI do seem to foster positive attitudes toward the computer and computer-assisted instruction.

5) What are the advantages of using CAI over other methods of instruction?

According to the literature examined, CAI has many advantages that other modes of instruction do not have. It provides immediate feedback, more easily individualizes instruction, increases social problem-solving skills, and increases the time spent on learning tasks. In addition, CAI can enhance students' self-esteem, motivate students, allow students to evaluate their own progress (Ryba and Chapman, 1983), and give them the opportunity to control their own environment.

A very important advantage of using CAI over other methods of instruction is that of savings in time. In all studies in which savings of time were measured, there was a substantial savings of student learning time. This advantage means that teachers can teach more topics (Bright, 1983), and that they can spend more time working with groups or individual students (Forman, 1982; Harrod and Ruggles, 1983).

6) What limitations does CAI have?

There seem to be four major limitations to the effective use of CAI. First is the poor quality software that is on the market today. In order to use CAI successfully, software packages must be educationally sound and meet the needs of the user (Placek, 1985). Better software can be designed through the efforts of educators and computer professionals working together (Kontos, 1984).

Another limitation pointed out by many of the authors is that of teacher training. Very few teachers are trained to use CAI. All of the positive effects attributed to CAI will not materialize if used inappropriately.

A third major limitation is that of CAI systems costs. At one time, a CAI system was not affordable to most school corporations, but these costs are now coming down (Pressman and Rosenbloom, 1984).

The fourth limitation involves the students. A number of authors pointed out that due to different factors such as personality, mental processing, and attitudes, all children will not benefit from CAI.

Although there are limitations to the effective use of CAI, many authors conclude that with the reduction of costs, the increase in good quality software, and the emphasis on training the teacher in the uses of computers and CAI, many limitations will be eliminated.

Final Conclusions

Computer-assisted instruction can become a valuable learning tool that can be used at many age and ability levels. If used with efficient and reliable computers, and by trained teachers, the use of CAI programs can result in computer literacy and achievement gains, and can instill in some children improved self-concepts, and motivation for learning. However, as was mentioned earlier in this paper, CAI is not a cure-all, nor is it suitable for each and every student. Careful consideration must always be taken as to

which child, group, or class could benefit from its use. Instead of being considered a cure-all, computer-assisted instruction should be considered as one of many effective instructional methods that can help a child to reach his fullest potential. This is the goal of education.

RECOMMENDATIONS

Based on the findings of the research concerning computer-assisted instruction, several recommendations can be made. The recommendations are as follows:

1) More research should be conducted to assess the effects of CAI on the personal growth and development of the student. In addition to achievement gains, CAI may positively increase self-esteem, and may decrease disruptive classroom behavior. Studies should assess the effect of CAI on the social behavior of older students, not just those in the preschool or in the primary grades.

2) As the computer directly or indirectly affects all of us, it is necessary to develop computer literacy. The schools need to expose students of all ages to the computer. This exposure can come through the actual teaching of computer literacy, and through the use of the computer with CAI or word processing programs.

3) Before CAI is used in the classroom, each school should assess the needs of its students, and the goals of the school. CAI should not be "thrown" into the

curriculum, without assessing where and how it can best be used.

4) All teachers, regardless of the subject taught or the level at which they teach, should be trained in the uses of computers and CAI through either pre-service courses, or in-service workshops.

5) Administrators and teachers need to be well informed as to what constitutes quality software, and should attempt to preview and evaluate all software before implementing into the classroom.

6) Before using CAI in the classroom, the teacher needs to seriously consider the characteristics and needs of the group or student, and whether CAI is actually the best way to achieve set objectives.

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